FLOODPROOFING:
A GUIDE FOR PROPERTY OWNERS

SECTION 206: FLOOD PLAIN MANAGEMENT ASSISTANCE

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

New England Division

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Contents

I AUTHORITY AND ACKNOWLEDGEMENTS

The authority for the preparation of this report is contained in Section 206 of the Flood Control Act of 1960 which authorizes the U.S. Army Corps of Engineers "...to compile and disseminate information on floods and flood damages...and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard."

This report has been published by the New England Division, U.S. Army Corps of Engineers, for use by private individuals in evaluating measures to reduce flood damage. It contains excerpts from a paper by Dr. James Dexter and from several previous Corps publications.

II PREFACE

The purpose of this report is to provide the individual property owner with information on various FLOODPROOFING options that can be implemented to reduce flood damages.

Floodproofing measures have limited ability to diminish flood losses, and the homeowner or businessperson should not be misled into thinking he or she has total flood protection. Particular care must be taken to insure that the perils of remaining in a flood threatened location are understood. Floodproofing can protect against property loss, but it should not be considered a protection against physical injury. Nevertheless, floodproofing in some situations can be used to effectively reduce losses from flooding, and in those cases it should be fully evaluated as an option available to the homeowner and businessperson.

III FLOOD DAMAGE PREVENTION

In the overall context of flood damage prevention, measures for reducing or preventing damages can be divided into corrective and preventive measures (Figure 1). Reservoirs, levees, channel improvements and watershed treatment are types of flood control measures aimed at keeping floodwaters within established channel banks or floodway limits and are characterized as corrective measures. Land use controls, commonly known as "Flood Plain Regulations," comprise those measures of floodway designation, encroachment lines, zoning, subdivision regulation and building codes that can be used to lessen the damaging effects of floods on future or potential development. They are characterized as preventive measures.

The measures themselves are implemented at every level of government -- Federal, State, regional and local -- as well as by the individual. The focus of this guide is on floodproofing with information geared toward the individual homeowner or businessperson.

IV WHAT IS FLOODPROOFING

Floodproofing means making a building and its contents more resistant to flood damage. It can reduce flood damage and make occupation of flood hazard areas more bearable.

Unless the protection level is exceeded, floodprooofing a structure will:

- Reduce the frustration of cleaning up after floods.
- Provide a reward in the form of less damage and repair cost over a long period of time.
- Cost less than you think, in some cases.
- Offer an additional tool in a comprehensive flood damage reduction program.
- Increase the protection afforded by partial protection flood control projects.
- Possibly improve the cost of flood insurance.
- Increase interest in flood damage reduction programs by heightening the awareness of flood risk.

Floodproofing a house will not:

- Be effective for large floods that exceed the design level.
- Solve all problems caused by floods.
- Provide for occupancy of buildings during floods, in most cases.

Floodproofing is not a cure for all flood problems. Rather, it should be considered one device among many available flood damage reduction measures, including land use regulation and change, flood control projects, flood fighting, flood relief and flood insurance. A comprehensive flood plain management program would ordinarily include the use of several or all of these techniques.

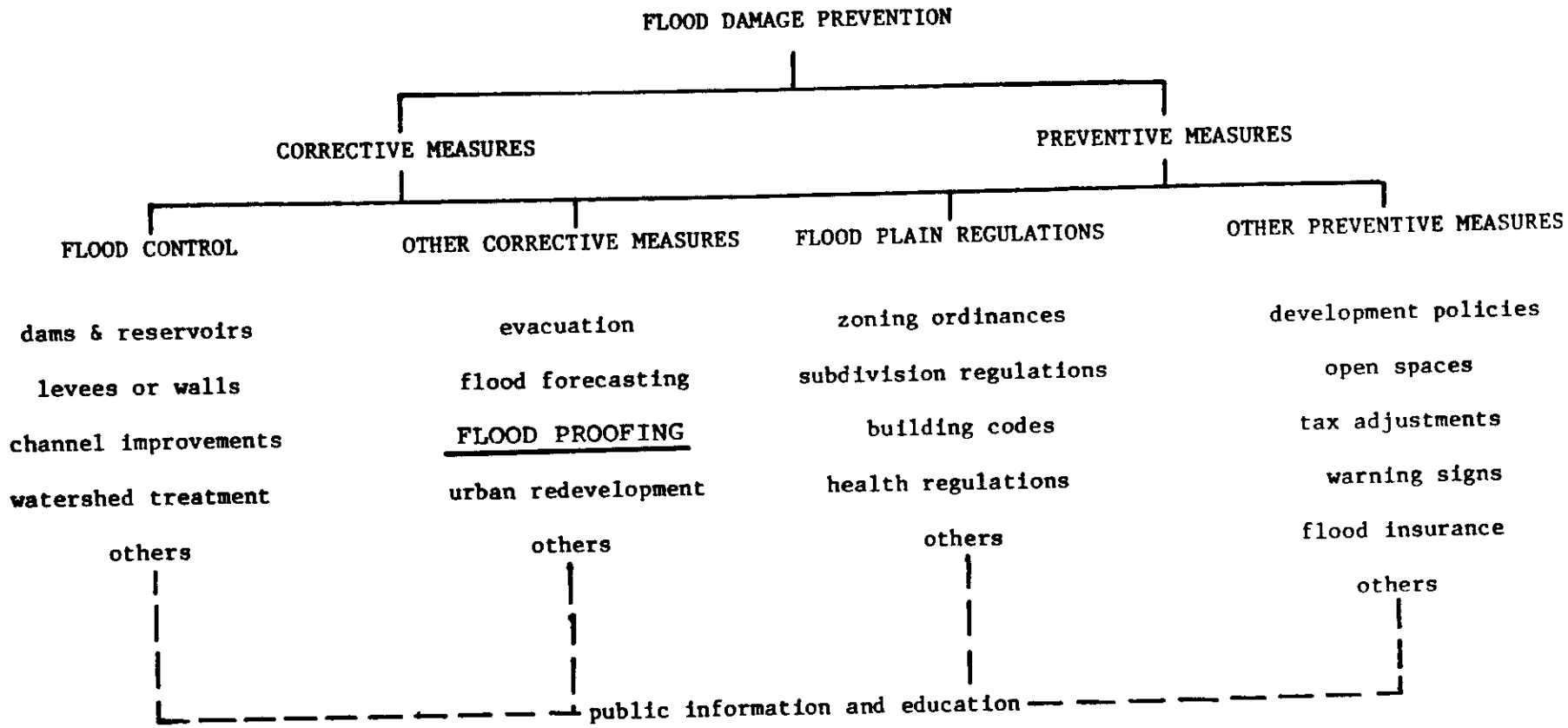

FLOOD DAMAGE PREVENTION
CORRECTIVE MEASURES
PREVENTIVE MEASURES
FLOOD CONTROL
OTHER CORRECTIVE MEASURES
FLOOD PLAIN REGULATIONS
OTHER PREVENTIVE MEASURES
dams & reservoirs
levees or walls
channel improvements
watershed treatment
others
evacuation
flood forecasting
FLOOD PROOFING
urban redevelopment
others
zoning ordinances
subdivision regulations
building codes
health regulations
others
development policies
open spaces
tax adjustments
warning signs
flood insurance
others
public information and education

FIGURE 1

V THINGS YOU SHOULD KNOW BEFORE YOU BEGIN

Flood Elevations

There are several sources of information on flood heights:

- The Federal Emergency Management Agency (formerly Federal Insurance Administration) prepares the official "Flood Insurance Rate Maps" and "Flood Hazard Boundary Maps." Individuals can use these maps to determine flood elevations along most major streams.

- The Corps of Engineers and other Federal agencies have completed studies for selected flood hazard areas. These studies include flood elevations. The Flood Plain Management Section, New England Division, U.S. Army Corps of Engineers maintains a record of where the most recent Federal information on flood elevations can be found.

- State, regional or local governments may also have some flood information.

Lowest Floor Elevation of Your Building

A professional land surveyor can determine the lowest floor (including the basement) elevation of your building.

Comparing Flood and Floor Elevations

To determine the extent of the flood hazard at your building, simply subtract the floor elevation from the flood elevation. This will tell you the expected depth of water at your first floor for a particular flood frequency (Figure 2).

Note: Flood elevations are generally referenced to the National Geodetic Vertical Datum (NGVD) formerly known as Mean Sea Level of 1929 (MSL). BE CERTAIN THAT YOUR BUILDING ELEVATIONS ARE REFERENCED TO THE SAME DATUM -- NGVD.

Flood Frequency Information

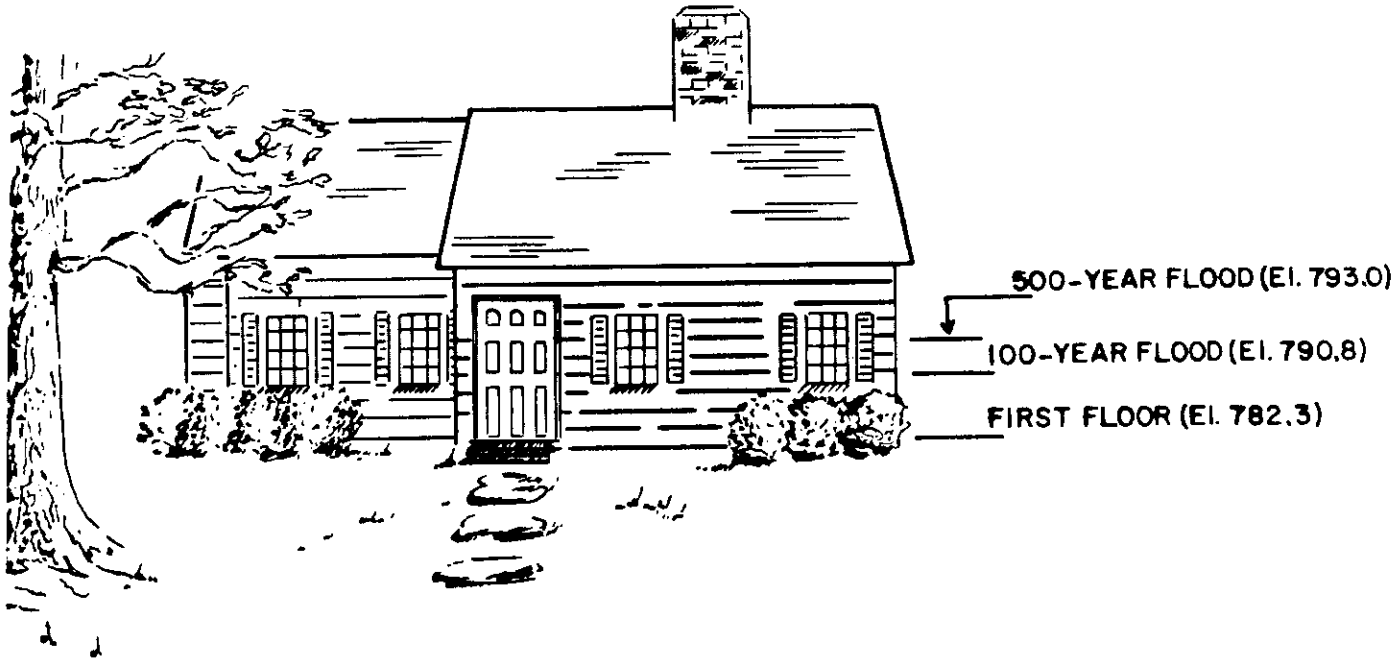
Generally flood elevations refer to a flood frequency. It is important to understand the concept of flood frequency before decisions on investments in floodproofing are made.

When you read a flood information report, you will find that hydrologists discuss various frequency floods (i.e., 50-year flood, 100-year flood, 500-year flood). To simplify this terminology, use the following table to get an indication of the chance that a given flood will be equaled or exceeded in any year:

Flood Frequency	Chance That The Flood Will Be Equaled or Exceeded in Any Year
500-year	0.2%
100-year	1%
50-year	2%
10-year	10%
5-year	20%

Flood frequency computations are based on records of floods that have occurred in the area over a long period of time. Remember, these computations show long run averages. You can have 100-year floods 2 years in a row or even in the same year!

You can use flood frequency data to compute your chances of being flooded. For example, suppose the first floor of your building, is at elevation 875.0 NGVD and the elevation of the 5-year flood is 875.0 NGVD. You then have a 20 percent chance of a flood reaching your first floor during any year.



NOTE : ALL ELEVATIONS REFERENCED TO NGVD

COMPARE FLOOD AND FLOOR ELEVATIONS

FIGURE 2

VI BE PREPARED FOR THE WORST

A floodproofing plan will not necessarily prove adequate for a very large flood. Thus, a dangerous situation can develop if you are not prepared for this possibility. The following are actions you can take to prepare for a catastrophic flood:

- First, any floodproofing package you use should have a "safety valve" in case its maximum effectiveness is exceeded. This should be designed to permit flooding to occur at the maximum floodproofed level with a minimal destructive force. For example, a floodwall or dike should have an overflow area where water can spill safely into the protected area.

- Second, plan ahead on how contents can be moved to higher levels of the building if it appears your first line of defense, such as floodwall, will be overtopped.

- Third, make sure you have an escape route if the flood depth becomes dangerous, and leave ample time to use it. Preplan with your family or employees to leave the structure when floodwaters reach a specific level. Remember, it is better to leave too soon safely than to wait and find yourself stranded. Surrounding roads may flood out sooner than the area around your building.

- Fourth, purchase and use a radio that receives the National Oceanic and Atmospheric Administration (NOAA) weather radio broadcast. NOAA broadcasts weather reports on three frequencies: 162.400 MHz, 162.475 MHz and 162.550 MHz (see below for a list of New England broadcast centers and their frequencies).

- Finally, keep your flood insurance policy active.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION BROADCAST FREQUENCIES

Broadcast Center	Frequency (MHz)
Hartford, Connecticut	162.475
Meriden, Connecticut	162.400
New London, Connecticut	162.550
Ellsworth, Maine	162.400
Portland, Maine	162.550
Boston, Massachusetts	162.475
Hyannis, Massachusetts	162.550
Concord, New Hampshire	162.400
Providence, Rhode Island	162.400
Burlington, Vermont	162.400
Brattleboro, Vermont	162.475

VII FLOODPROOFING OPTIONS FOR THE PROPERTY OWNER

Floodproofing Measures

Floodproofing measures can be classified into three broad categories. First, are permanent measures which become an integral part of the structure or land surrounding it. Second, are temporary or standby measures that are used only during floods, but are constructed and made ready prior to any flood threat. Third, are emergency measures that are carried out during flood situations in accordance with a predetermined plan.

Only the first two types of measures will be discussed in the following sections, which will focus on their use in existing structures located in flood hazard areas.

Individual Analysis

It is possible to significantly reduce damages and save on repair bills even if your structure is flooded only once. You can install some of the floodproofing measures discussed in this report by yourself, or with minimal help, by relying on your previous experience with floods. Most measures, however, require help from a professional engineer and/or a building contractor.

Cost estimates for floodproofing measures are provided for each floodproofing method discussed. IT SHOULD BE UNDERSTOOD THAT THE COSTS ARE ESTIMATES AND THAT YOUR COSTS MAY VARY. Dollar figures in this report are referenced to December 1980 prices.

The costs and savings for your building depend on:

- Your exposure to floods.
- The size and type of your building.
- The way you use the parts of the structure exposed to floods.

The following pages outline five basic floodproofing methods:

1. Rearranging or protecting damageable property within an existing structure.
2. Installing temporary or permanent closures for openings in existing structures.
3. Constructing small walls or dikes around existing structures.
4. Raising existing structures in place.
5. Relocating existing structures and/or contents out of a flood hazard area.

Many of these measures are equally applicable to protection of new structures or can be implemented when making major improvements (see Section VIII, "Construction Improvements to Existing Structures," for a summary).

Local, State and Federal regulations pertaining to modifications in the flood plain and streambed may require permits before construction. Check with your local government and other regulatory bodies to insure that you fulfill all permit and/or building code requirements.

Some nonstructural measures, such as flood shields for doorways and windows, gates for openings in walls or dikes, and evacuation of people and property, require warning time to implement. The reliability of protection provided by measures that require warning is obviously less than those that require no warning. In fact, lead time may mean the difference between protection and no protection.

METHOD 1

REARRANGING OR PROTECTING DAMAGEABLE PROPERTY WITHIN AN EXISTING STRUCTURE

Method 1 minimizes the way water comes in contact with damageable items. It can involve either minor or major modifications to the structure, selecting specific types of contents, and taking preparatory, emergency and cleanup actions (Figures 3-5). Actions to be taken under Method 1 are listed in Table 1. Many items in this package can be accomplished by the property owner with minimal outside help. A disadvantage is that water will still enter the building and cause damage to the structure and unprotected contents.

Residential Applications

Some measures in Method 1 can be easily and cheaply implemented by the property owner. The rearrangement or raising in place of contents within a structure is easily accomplished and can result in significant savings should a flood occur. Utility cells and rooms, while effective floodproofing measures, are expensive and require professional expertise. Because of the expense involved, utility cells and rooms are applicable only to those property owners who experience high flood damages.

Commercial and Industrial Applications

The rearrangement or raising in place of contents within a structure is equally applicable to commercial and industrial structures. Cells, elevated rooms or interior floodwalls may be more feasible for commercial industrial structures because of the generally high cost of repair or replacement of their mechanical equipment.

Physical Feasibility

The degree to which property can be rearranged and protected is site specific. It depends on the flood hazard, principally depth and frequency of flooding, and the damageable property and its type, value, location and mobility. Shallow flooding allows the use of protective types of measures where appliances, utilities, equipment, and goods can be raised in place, surrounded, or enclosed and protected. Where the hazard is more severe and inundation is to greater depths, property will need to be relocated to prevent damage.

Residual damage to both structure and contents will remain even when property is rearranged or protected. For this reason, protection of property seems to be given most serious consideration when other measures are either not physically or economically feasible, or the depth of flooding is relatively shallow.

TABLE 1
REARRANGING OR PROTECTING DAMAGEABLE PROPERTY
WITHIN AN EXISTING STRUCTURE

Actions for Utilities and Equipment

1. a) Raise the hot water heater, air conditioner, furnace and appliances (washers, refrigerators, etc.) onto concrete blocks or platforms.
   b) Relocate utility area (usually a separate room) to elevation above flood elevation.
   c) Construct watertight cell around utilities at their present location.
   d) Construct interior floodwalls around critical equipment.

2. Provide drains in the heating and air conditioning ducts below expected flood levels so they will not collapse under the weight of retained water as the flood recedes.

3. Raise all electrical receptacles or put them on branch circuits separate from overhead lighting.

4. Install a manual sewer cutoff valve outside the structure.

5. Finished basement ceilings should have clearances between moldings and walls to permit drainage of retained water.

Actions for Contents

1. All cabinetry should be raised or made from metal to be water damage resistant.

2. Carpeting and carpet cushions should be of an outdoor type, manufactured from materials that can withstand immersion in water. Salvage is more economical than replacement. Finished flooring materials should be water damage resistant and adhesives should be stable after immersion.

3. Paints and applied finishes should be water damage resistant brands, which will remain serviceable and attractive after surface washing.

Preparatory Actions

1. Tune your radio to a station that broadcasts National Oceanic and Atmospheric Administration weather reports (see page 5).

2. Do not store damageable items in low areas, if possible.

3. PREPARE A LIST OF THINGS TO DO to be implemented as soon as you hear a general flood warning broadcast:

   a) move cars to higher ground.
   b) secure lawn furniture and tools.
   c) stack sandbags around openings to give you extra time to move things.
   d) unhinge interior doors to make tables for stacking posessions.
   e) roll up small rugs.
   f) move lighter posessions to a safe place such as an attic.

Emergency Actions

1. In the event you notice water rising quickly, HAVE A PRE-ARRANGED PLAN:

   a) turn off utilities.
   b) use a hand truck to move heavy appliances such as washing machines to higher floors or higher ground.
   c) stack furniture on concrete blocks; use doors laid on blocks as tables to stack drawers, lamps, clothing, photos, etc.
   d) roll up rugs, tie up curtains and draperies.

2. HAVE A PRE-ARRANGED ESCAPE ROUTE IF THE WATER SHOULD GET DANGEROUSLY HIGH AND ALLOW YOURSELF ENOUGH TIME TO USE IT BEFORE IT IS CUT OFF.

Advantages

. Almost every property owner can implement this method to one degree or another.

. It can be done on a per item basis, thus reducing the cost and allowing selective protection of high value contents.

. A structure can continue to be used at its existing site.

Disadvantages

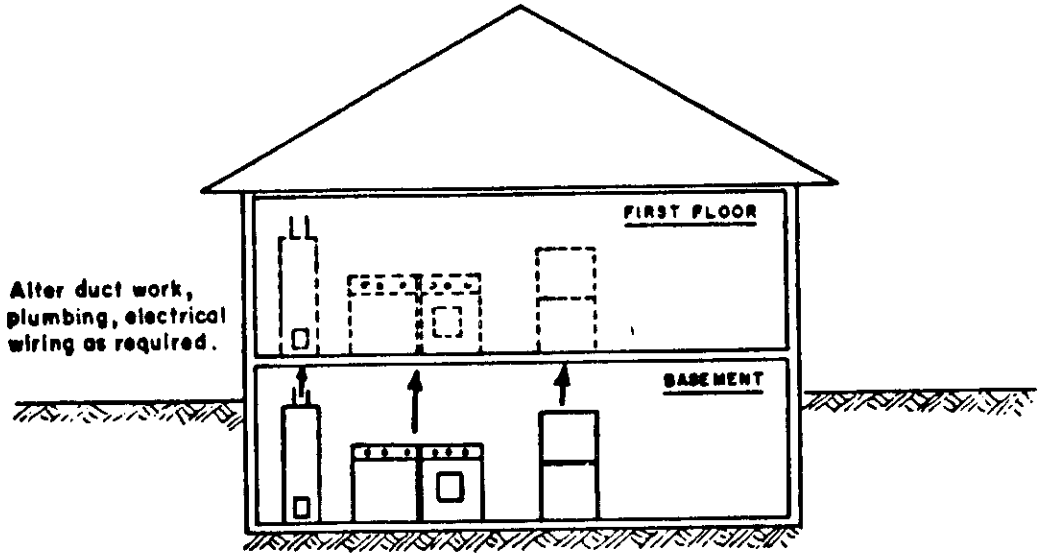
. Damage can be reduced only on those items that can be relocated or protected.

Economic Feasibility

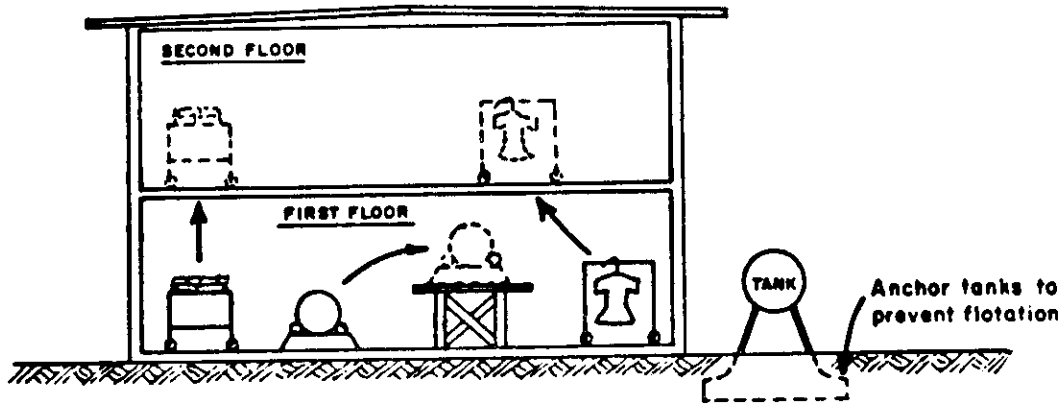
When damageable property is rearranged or protected within a structure, damage is reduced because the property is less susceptible to flooding. Because this type of measure deals principally with individual property items, an assessment should probably be made that considers the cost to relocate or protect, the damage caused by flooding, the frequency of flooding, the inconvenience, and the availability of alternative locations.

Although many of the actions are relatively inexpensive, protection of utilities such as the furnace and electrical box can be costly. For example, cost estimates for constructing utility cells or rooms of a type shown in Figures 4 and 5 are:

	Estimated Total Cost
Utility Cell	$13,700
Utility Room	$8,000



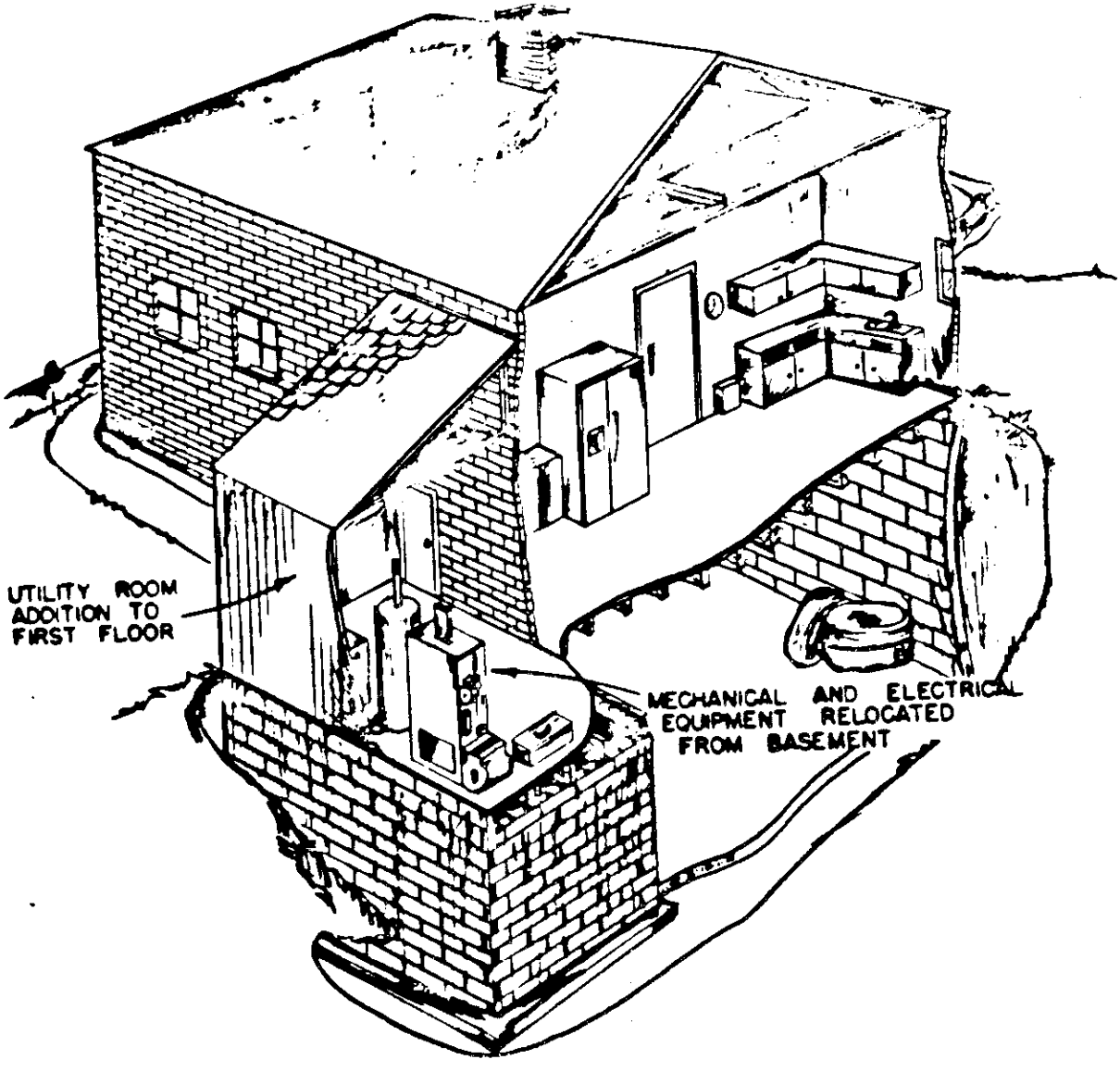
Raise Furnace, Water Heater, Washer, Dryer to First Floor



Raise and Relocate Merchandise and Equipment, Anchor Floatable Items.

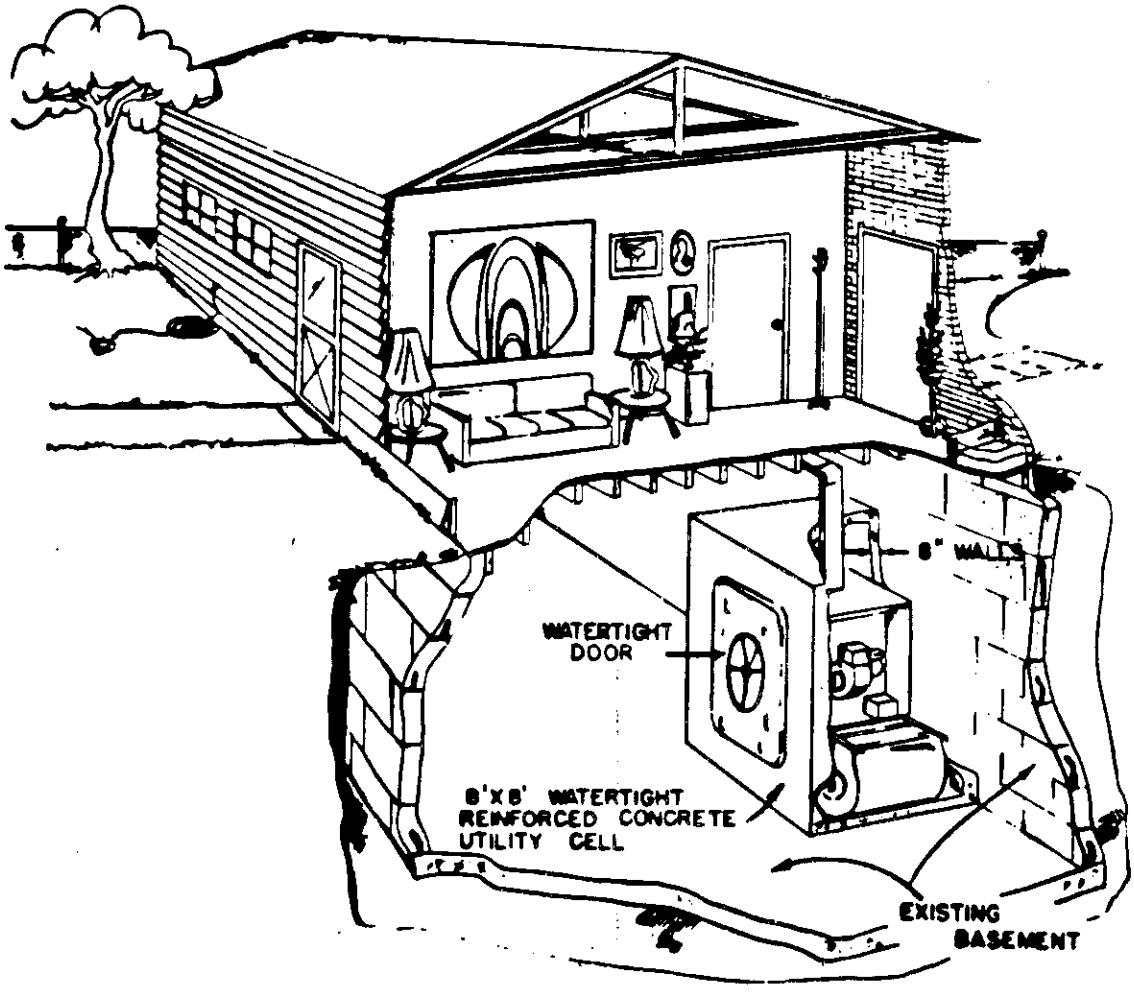
Rearranging or Protecting Existing Property

FIGURE 3



RELOCATION OF HOUSEHOLD MECHANICAL
AND ELECTRICAL EQUIPMENT TO FIRST FLOOR

FIGURE 4



Protection of Existing Utility Equipment

FIGURE 5

METHOD 2

INSTALLING TEMPORARY AND/OR PERMANENT CLOSURES

Structures whose exterior is relatively impermeable to water can be designed to keep floodwaters out by installing watertight closures to openings such as doorways and windows as shown on Figure 6. Due to the hydrostatic and buoyant pressures floodwaters exert on the building's walls and basement, this method is better suited for commercial and industrial structures that are more structurally sound. While some seepage will probably always occur, it can be reduced by applying sealants to walls and floors and providing floor drains where practical. Closures may be temporary or permanent. Temporary closures are installed only during a flood threat and therefore need warning time before installation. Specific measures that may be undertaken are described in Table 2.

Residential Applications

Due to buoyant and hydrostatic pressures, closures are not recommended for most residential structures that are not normally designed to withstand such loads. A second drawback is the possibility of incurring flood damage in the event a closure is neglected or fails to function as intended due to improper placement.

Commercial and Industrial Applications

Generally, closures are better suited to commercial and industrial structures that may be capable of withstanding buoyant and hydrostatic pressures. Permanent masonry closures have been effective in preventing flood damages at many industrial riverine sites in New England.

Physical Feasibility

Most structures, whether residential, commercial or industrial, are not designed to withstand hydrostatic pressure on the exterior walls. Therefore, when discussing physical feasibility, the principal considerations are that, 1) the exterior walls are impermeable or can be made so, 2) all openings below the design level can be closed, and 3) THE STRUCTURE CAN WITHSTAND THE ANTICIPATED HYDROSTATIC PRESSURES INCLUDING BUOYANT.

When water is prevented from entering a structure, the walls become subject to lateral and hydrostatic forces that may cause failure, and the basement floor is subject to uplift forces that may cause buckling or flotation. Most structures are not designed to carry these forces and consequently are in danger of collapse or floating if floodwaters rise too high. It is particularly difficult to analyze the capability of existing structures to resist these forces because of the general lack of knowledge about workmanship and materials used during construction and the present condition of these materials. As a result, it is recommended that the property owner seek advice from an engineer or architect regarding the feasibility of these measures before implementation.

TABLE 2

TEMPORARY AND/OR PERMANENT CLOSURES

ACTIONS

1. Floodproof sewer lines and other plumbing facilities by the installation of backflow valves

2. Have on hand and in good working order all equipment necessary for installation of flood shields (tools, nuts, bolts, etc.). Flood shields are normally fabricated of aluminum, steel or wood. These shields should be no higher than 2 feet so that water pressure will not cause structural damage (shields could be higher for some commercial or industrial buildings). They should be stored nearby for installation during a time of flooding.

3. Place sandbags over the flood shield to insure its effectiveness.

4. Permanently close nonessential openings with masonry or other relatively impermeable materials.

5. Install sump pumps to remove any seepage that is likely to enter the structure even though it has been made generally watertight. The pump discharge must be installed above the expected level of flooding.

CAUTIONS

1. THIS METHOD WILL NOT WORK FOR FLOOD DEPTHS GREATER THAN 2 FEET. PROVIDE FOR OVERFLOW INTO HOUSE AT THIS DEPTH. GREATER DEPTHS CAN CAUSE SEVERE STRUCTURAL DAMAGE TO WALLS AND DOORS. Commercial and industrial structures may be able to withstand greater flood depths.

2. Basement or exterior walls must be essentially impermeable, not usable if exterior is wood siding.

3. A sump pump is needed to collect infiltration. Be sure it's heavy duty — 1/2 horsepower or larger.

4. A good alarm system is needed to alert you of floods at night or during off business hours to insure enough time to install shields. Cooperate with your neighbors to warn each other of floods and to help each other install shields. Show them how to install shields before you go on vacation.

5. Brick veneer may need reinforcing.

6. CHECK TO INSURE THE STRUCTURE IS PROPERLY ANCHORED TO THE FOUNDATION. OTHERWISE, THE BUILDING MAY FLOAT.

Advantages

- May be done on a selective basis to only those openings through which water enters and only to the height desired.
- Easy and quick to implement.

Disadvantages

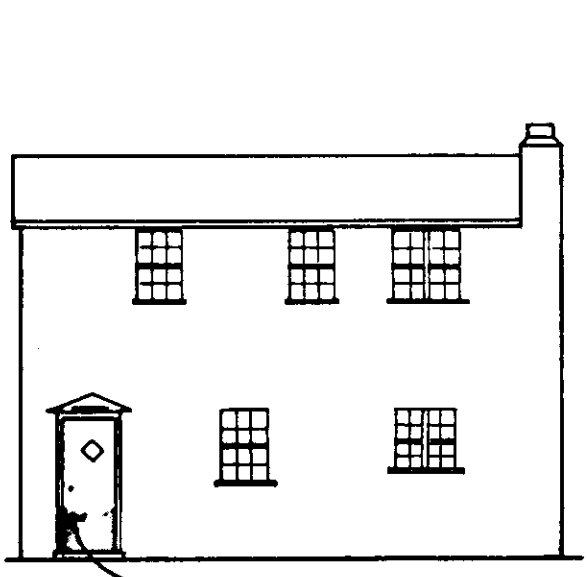
- In the case of residential structures, is applicable only to those with brick or masonry type walls, without basements, which can structurally withstand the hydrostatic and uplift pressure of the design flood, and which are generally watertight. This disadvantage also applies to commercial and industrial structures, except that the walls and basements may be capable of withstanding greater pressures.
- Reduced likelihood of effective implementation at night, and during vacations and off-business hours.
- May create a false sense of security and induce people to stay in the structure longer than they should.

Economic Feasibility

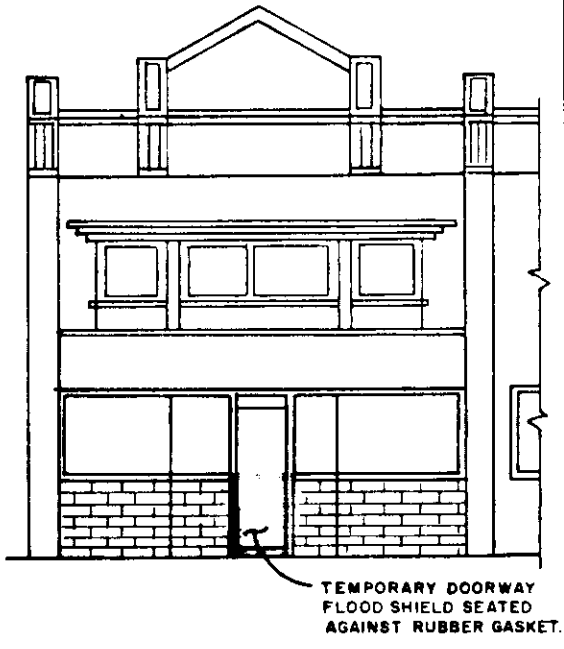
When floodwater is prevented from entering a structure, damage is reduced up to the design level of the protection provided. When a flood exceeds the protection level, damage occurs as it normally would without protection. The damage reduced includes damage to contents and structure interior. Damage to structure exterior and the site still remain. Cost estimates for this type of floodproofing measure are as follows:

	Estimated Cost
Flood Shields (3-3'x2' aluminum, installed)	$1,380
Sewer Gate Valve	430
Total Cost	$1,810

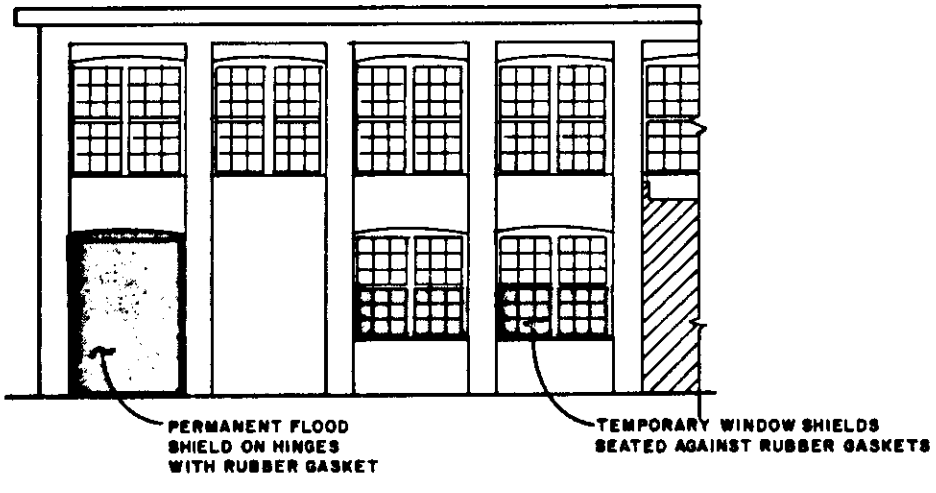
Estimated for a $30,000, 1,600 square foot structure with front, rear, and side entrances. Closure to 2 feet above first floor. Costs include 25 percent for contractor's bonds, overhead, profit and engineering.



TWO STORY BRICK
RESIDENTIAL STRUCTURE



ROW STRUCTURE



COMMERCIAL / INDUSTRIAL STRUCTURE

Temporary and Permanent Closures

FIGURE 6

METHOD 3

CONSTRUCTING SMALL WALLS OR DIKES

Method 3 minimizes the ways in which water can reach your home. It requires constructing walls or dikes (Figure 7). Walls and dikes are designed to protect one or several structures (see Table 3 for specific actions), and are built to be compatible with local landscape and aesthetics as shown in Figure 8. Walls may be of various masonry materials designed to resist the lateral and uplift pressures associated with flooding. Levees or dikes are usually constructed with an impervious inner core to prevent seepage and with slope protection where erosion is a problem. Where access openings are necessary, provisions must be made to close these openings during floods. This generally means providing a floodgate that can either be stored at the opening and installed when needed, or constructing it on hinges or rollers for automatic or semiautomatic closure.

During flood conditions it is possible for precipitation, seepage and runoff from roof drainage to cause water to accumulate inside a wall or dike and cause water damage to the property being protected. This problem can be reduced by providing interior drainage facilities to remove the water. Generally, this includes construction of a low-lying sump area to collect the drainage and a pump to remove it. As part of the interior drainage facilities, backup can be prevented by installation of appropriate valves in discharge lines. It is important that a professional engineer design this package, as the hydrostatic and hydrodynamic loadings may be greater than envisioned by the layman.

Residential Applications

Walls and dikes are effective in preventing damages, but are expensive and require professional assistance. Aesthetics and the amount of surrounding land area, especially in more urban areas, can also create problems for the property owner. Because it is a large and expensive undertaking, it is applicable only to those property owners who experience high flood damages.

Commercial and Industrial Applications

Where flood damages are high, walls and dikes are recommended for commercial and industrial structures, where aesthetics can be less restrictive.

Physical Feasibility

One particular advantage of a wall or dike is that it is not limited to a particular type or size of structure and therefore is feasible for any residential, commercial or industrial property. The question of physical feasibility centers on site conditions such as topography, available space and compatibility with existing use, and on the nature of flooding velocity and location relative to the structure being protected.

TABLE 3

SMALL WALLS AND DIKES

ACTIONS

WALLS

1. Construct reinforced block or stone wall, and footing.
2. Install internal drainage system including tile networks for underseepage, gravity drians, sump pump and other underground utilities.
3. Provide for openings for egress; protected by flood gates or removable flood shields.
4. Provide for overflow area or relief valve to permit floodwaters higher than the design to enter the enclosed area safely without structural damage to the house.

DIKES

1. Construct compacted earth fill dike with impervious core and seepage drains.
2. Install internal drainage system including tile networks, gravity drains, sump pump and cutoffs for sewer and other underground utilities.
3. Provide for overflow area or relief valve to permit floods higher than the design to enter the enclosed area safely without structural damage.

CAUTIONS

1. Architect-Engineering firm should be contacted to develop the plans.
2. Wall height is generally limited to 6 to 8 feet. Provide overflow area protected from erosion.
3. Access openings may be required. You will need to have warning to complete a closure or use manual gates.
4. Permission to build in the flood plain may be necessary. Check with your local zoning commission and State and Federal regulatory agencies.
5. An inadequate design may result in a greater damage than would have occurred without the wall or dike.

Advantages

- Not dependent upon the site, type or condition of property being protected.
- Protects property outside a structure.
- Can be aesthetically pleasing and provide privacy and security in addition to flood protection.

Disadvantages

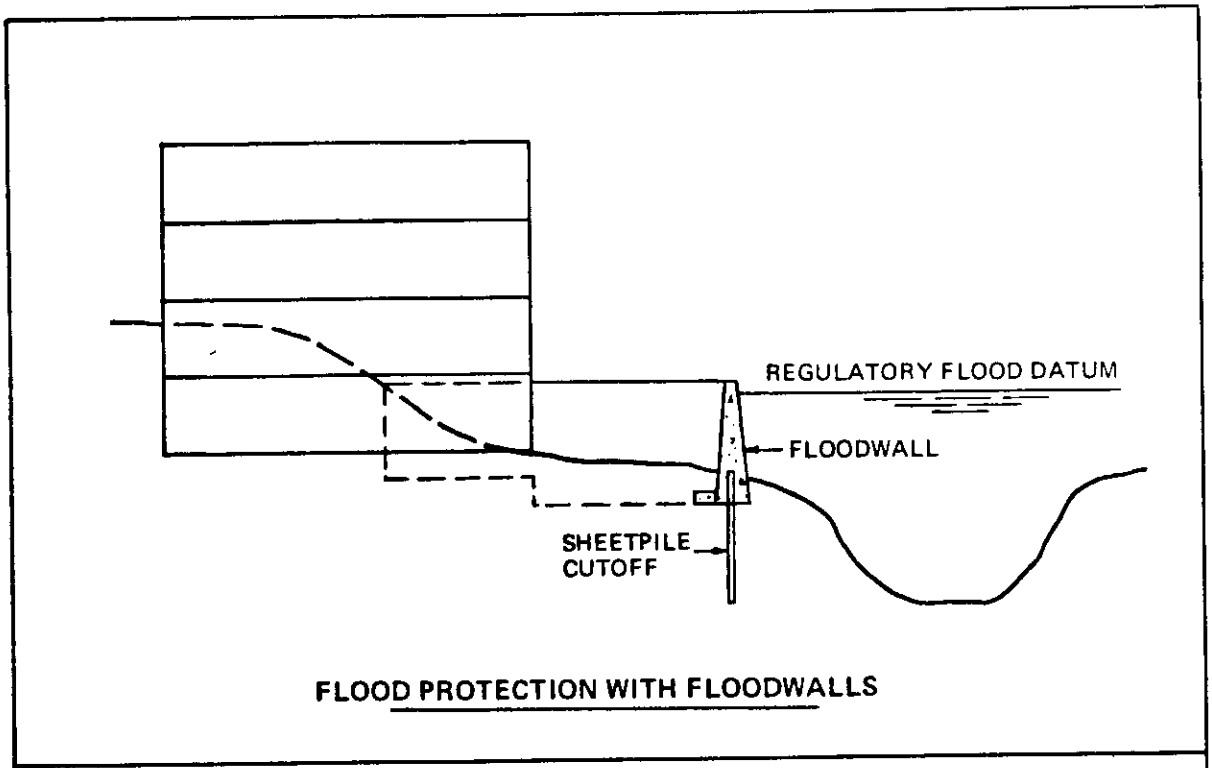
- Dependent upon site conditions: topography, property lines, available space, soil and ground water conditions, velocity and depth of flooding, and location of floodwater relative to structure.
- May require access openings which must be closed during a flood. If the closures are manual, a warning time is necessary.

Economic Feasibility

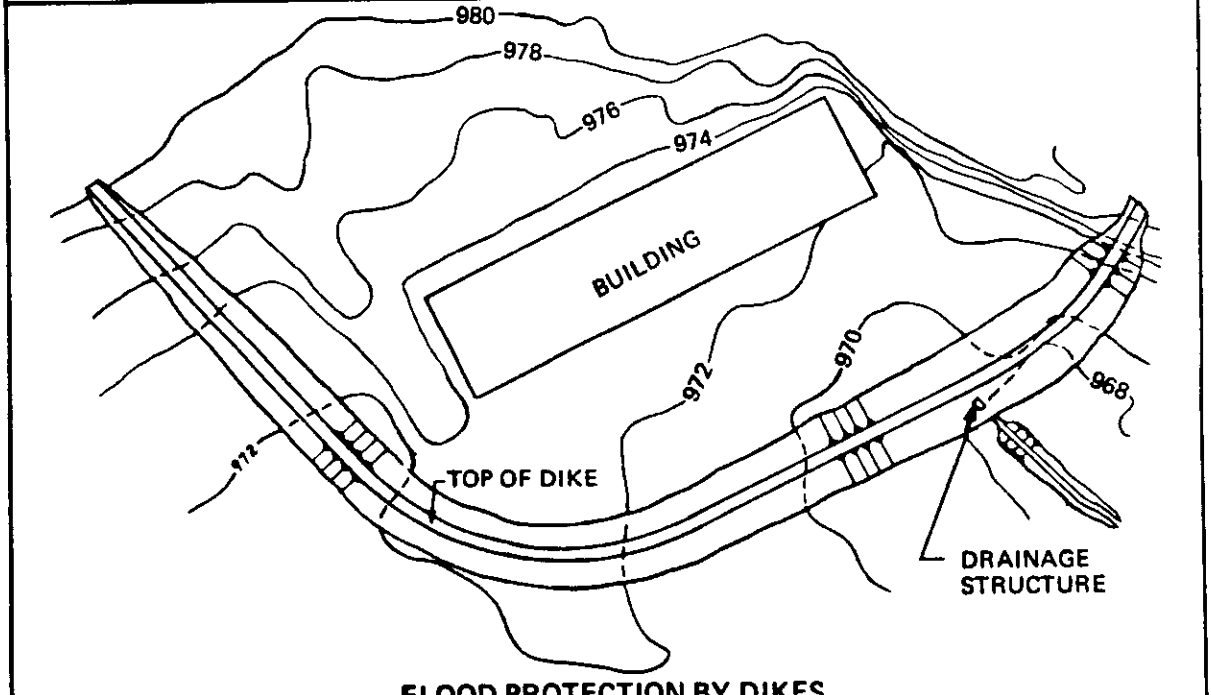
A small wall or dike will prevent damage to both structure and contents. Damage is prevented up to the design height of the wall or dike. Costs are as follows:

Item	Estimated Cost			
	Wall		Levee	
	3 feet	5 feet	3 Feet	5 Feet
Construct Wall or Levee	$4540	$6910	$1130	$2260
Provide Sump Pump	1340	1340	1340	1340
Install Sewer Gate Valve	430	430	430	430
Total First Cost	$6300	$8680	$2900	$4030

Estimated for a 1,600 square foot, $30,000 structure with or without basement. Protection assumed along backside of lot--140 feet for a wall and 216 feet for a levee. Costs include 25 percent for contractor's bonds, overhead, profit, and engineering.

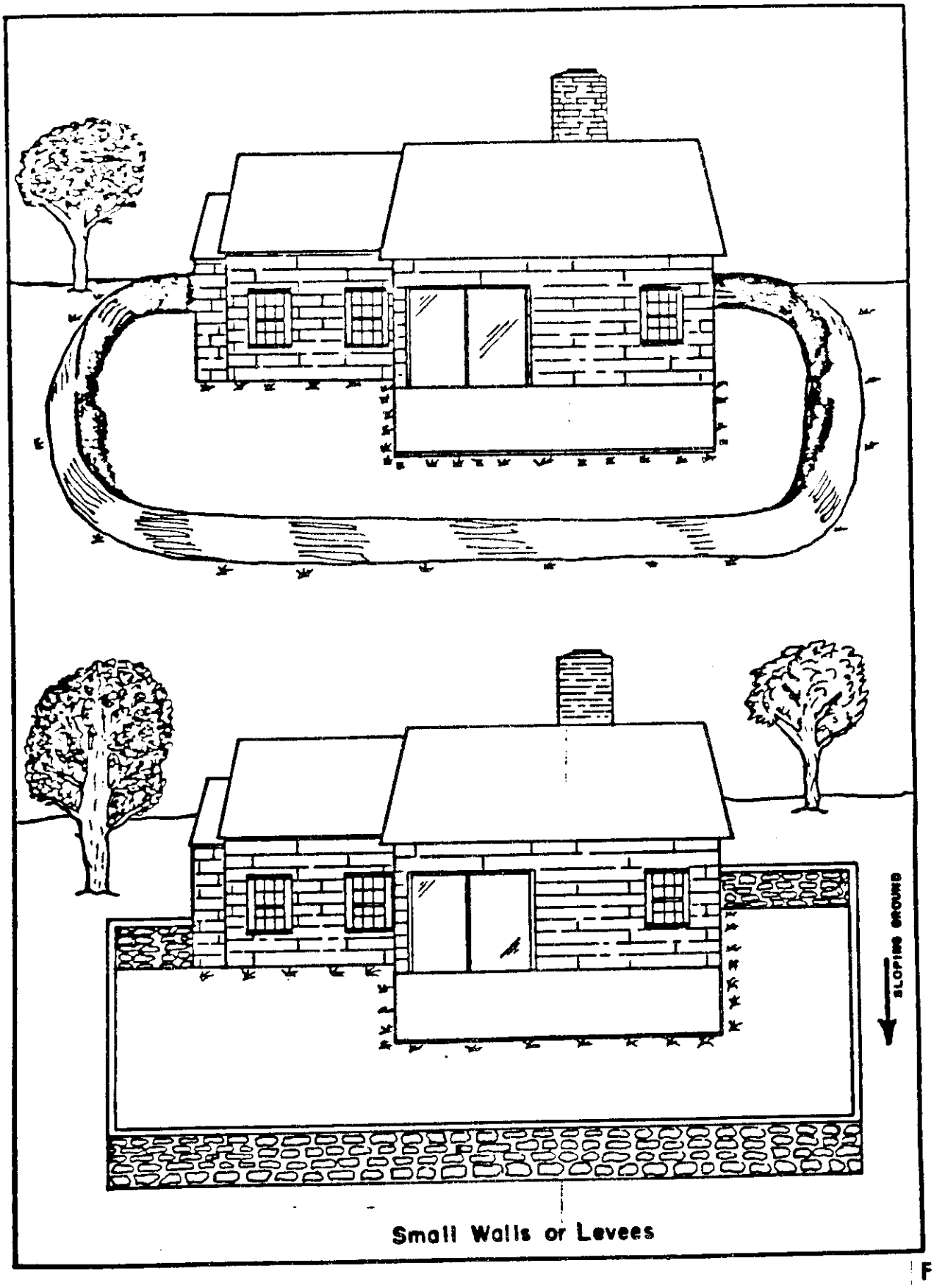


FLOOD PROTECTION WITH FLOODWALLS



FLOOD PROTECTION BY DIKES

FIGURE 7



Small Walls or Levees

FIGURE 8

METHOD 4

RAISING EXISTING STRUCTURE

Method 4 involves raising the structure above expected flood levels (Figure 9). In this method the building is raised on jacks by a professional mover and a new foundation is built and/or the lot is regraded to provide higher ground under the structure (see Table 4 for specific actions). The floodproofing method is not complete unless the building is evacuated during the early stages of a flood. Otherwise, people may become trapped inside and be in extreme danger should a catastrophic flood occur.

Residential Applications

The cost of raising a structure is the only serious drawback of this measure. Aesthetics and compatability with neighboring homes can be maintained by landscaping or applying adornments such as lattice work, to the area below the first floor. The expense of this method including professional assistance makes it applicable only to those homeowners who experienced high flood damages.

Commercial and Industrial Applications

Due to the size and usage requirements of most commercial and industrial structures, raising may not be physically feasible. The expense of raising a structure, assuming that raising is physically feasible, makes it an alternative to be considered only at those sites that experience high flood damages.

Physical Feasibility

Technology exists to raise almost any structure, however, raising-in-place from a practical viewpoint is most applicable to structures that can be raised by low-cost conventional means. Generally, this means structures that, 1) are accessible below the first floor level, 2) are light enough to be raised with conventional housemoving equipment, and 3) do not need to be partitioned prior to raising. Wood frame residential and light commercial structures with first floors above grade are particularly suited for raising. Structures with concrete floor slabs (slab-on-grade) and structures with common walls are not feasible to raise without special equipment involving additional expense.

Advantages

- Damage to structure and contents is reduced for floods below the raised first floor elevation.
- Particularly applicable to single and two-story frame structures on raised foundations.
- Structures have been raised to heights of up to 9 feet. Aesthetically, the greater heights are probably most acceptable in wooded areas of steep topography.

TABLE 4

RAISING THE STRUCTURE

Actions	Cautions
1. Unhooking, modifying, and re-hooking utilities	1. Generally limited to 8 to 10 feet above feet above present level.
2. Raising the structure.	2. Building permits may be needed - plan to spend a couple of months securing an architect or contractor and obtaining permits.
3. Constructing a new foundation and anchoring the house frame to it.	3. Occupants should evacuate the house when a flood is forecast. Otherwise, they may become stranded. Should the flood be larger than anticipated, the occupants lives would be in jeopardy.
4. Landscaping and architectural treatment of the new exterior.	

- The means of raising a structure are well known and contractors are readily available.
- Raising-in-place allows the user-owner to continue operations at the existing location.

Disadvantages

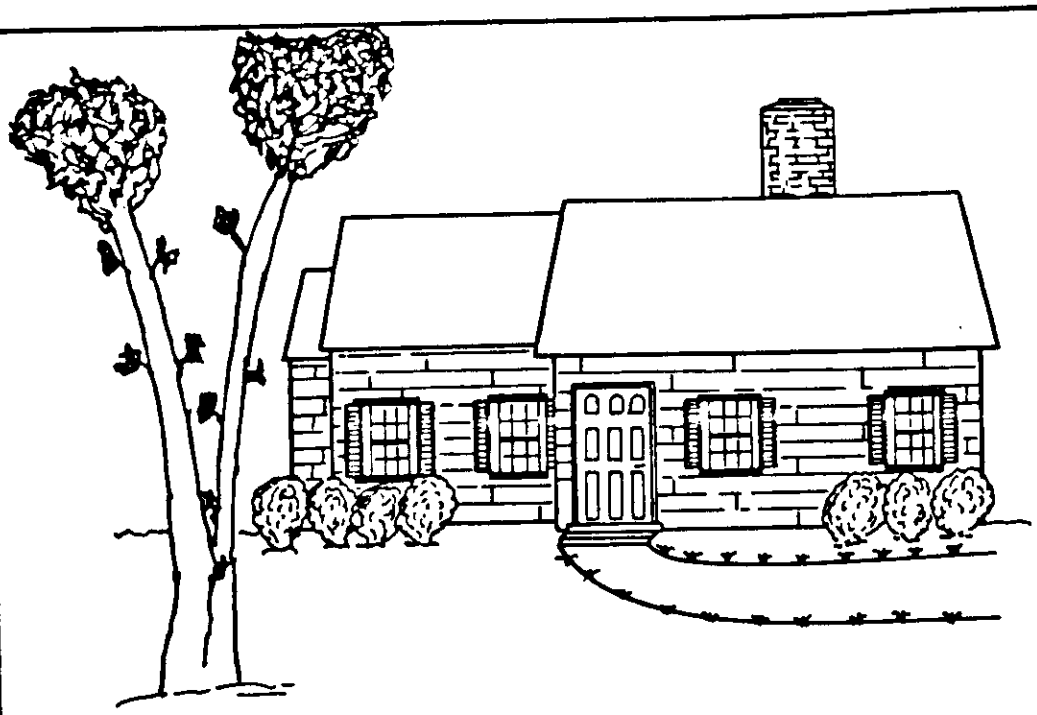
- Residual damages exist when floods exceed the raised first floor elevation. Minor damage may occur below the first flood depending upon use.
- Not generally feasible for structures with slab-on-grade foundations.
- Landscaping and terracing may be necessary if the height raised is extensive.

Economic Feasibility

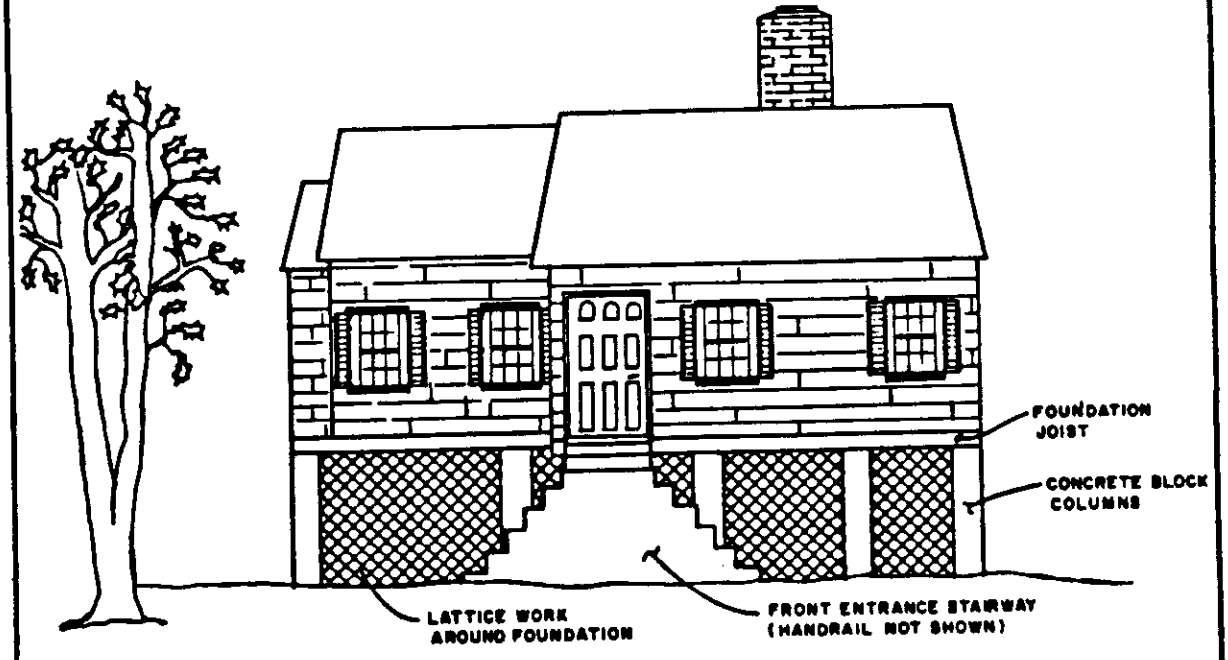
Raising a structure reduces damages that would have been caused by flood events had the structure not been elevated. Cost estimates for raising the superstructure and constructing a new foundation.

	Estimated Total Cost
Raising Structure in-Place	$11,000

Estimated for a 1,600 square foot, $30,000 structure without basement, on raised foundation. Height raised assumed to be 3 feet. Costs include 25 percent for contractor's bonds, overhead, profit, and engineering.



RESIDENCE BEFORE RAISING



RESIDENCE AFTER RAISING

Raising Existing Structure

FIGURE 9

METHOD 5

RELOCATING EXISTING STRUCTURES AND/OR CONTENTS

There are basically two options for removing property to a location outside the flood hazard area (Table 5). One is to remove both structure and contents to a flood free site, and the second is to remove only the contents to a different structure located outside the flood hazard area and demolish or reuse the structure at the existing site within the flood plain. Each of these options is shown in Figure 10.

In each case the purpose is to remove damageable property from the hazard area, yet take advantage of opportunities for using the existing property in ways that are compatible with the hazard.

Residential Applications

Both relocation of contents to a new structure and relocation of the entire structure to a new site are costly measures. Only homeowners with high flood damages should consider these measures.

Commercial and Industrial Applications

The relocation of the structure to a new site may not be physically feasible. Relocation of contents is most applicable at complexes where there may be alternative sites available for the relocation of high value merchandise or machinery.

Physical Feasibility

While the experience and equipment exist for moving many different types of structures, there is a practical limit on the size and type of structure that is economically feasible to move to reduce flood losses. Even the most readily relocatable structures are costly to remove.

One or two-story residential and light commercial structures of wood frame on raised foundations or basements are usually easy to move because of the structure weight and access to the first floor joists. Structures of brick, concrete or masonry can also be moved, however additional precautions must be taken to prevent excessive cracking.

Advantages

- Flood damage to the existing contents is eliminated. If the structure is demolished, structural damage is also eliminated.

Disadvantages

- Damage to the structure and site remain if the structure is to be reused.
- Costs to remove contents and demolish the structure are high relative to other measures.

TABLE 5

RELOCATION OF EXISTING STRUCTURE AND/OR CONTENTS

ACTIONS

Relocating the Structure

1. Unhook, modify and rehook utilities.
2. Construct a new foundation.
3. Raise and move structure to new foundation and anchor the building frame to the foundation.

Relocating Contents

1. Construct or purchase a structure outside of flood hazard area.
2. Move damageable contents to new structure.
3. Demolish old structure or preserve it for a new use, compatible with the flood hazard.

CAUTIONS

1. If structure is to remain in flood hazard area, the building and remaining contents will still be susceptible to flooding.
2. If structure is to be relocated, building permits may be required. Plan to spend a couple of months securing an architect or contractor and obtaining permits.
3. If the structure is to remain in the flood hazard ara, occupants should evacuate when a flood is forecast.

Economic Feasibility

With a structure and contents located at a flood hazard site, flood damage occurs. When both structure and contents are removed to a flood free site, this damage is eliminated. The damage reduced by removal is the amount of damage that would have occurred had the structure not been removed. Estimated costs are shown below.

	Estimated Total Cost
Relocate structure	$24,200

Estimated for a $30,000 1,600 square foot structure. Land value of a new site assumed to be $5,000. Costs include 25 percent for contractor's bonds, overhead, profit, and engineering.

Relocate contents and demolish existing structure	$46,000

Costs were estimated assuming a 1,600 square foot structure in a flood-free location was valued at $30,000 and land at $5,000.

The value of the structure in the flood hazard area was assumed to be $5,000 below market value of structures at flood-free sites and land value was assumed $500.

Costs include 25 percent for contractor's bonds, overhead, profit and engineering.

Replacement cost is sometimes interpreted as being the additional cost to provide a comparable structure at a flood-free site. Under this interpretation this cost could be over $9,500 since an additional $5,000 would be needed for a comparable structure and $4,500 for flood-free land.

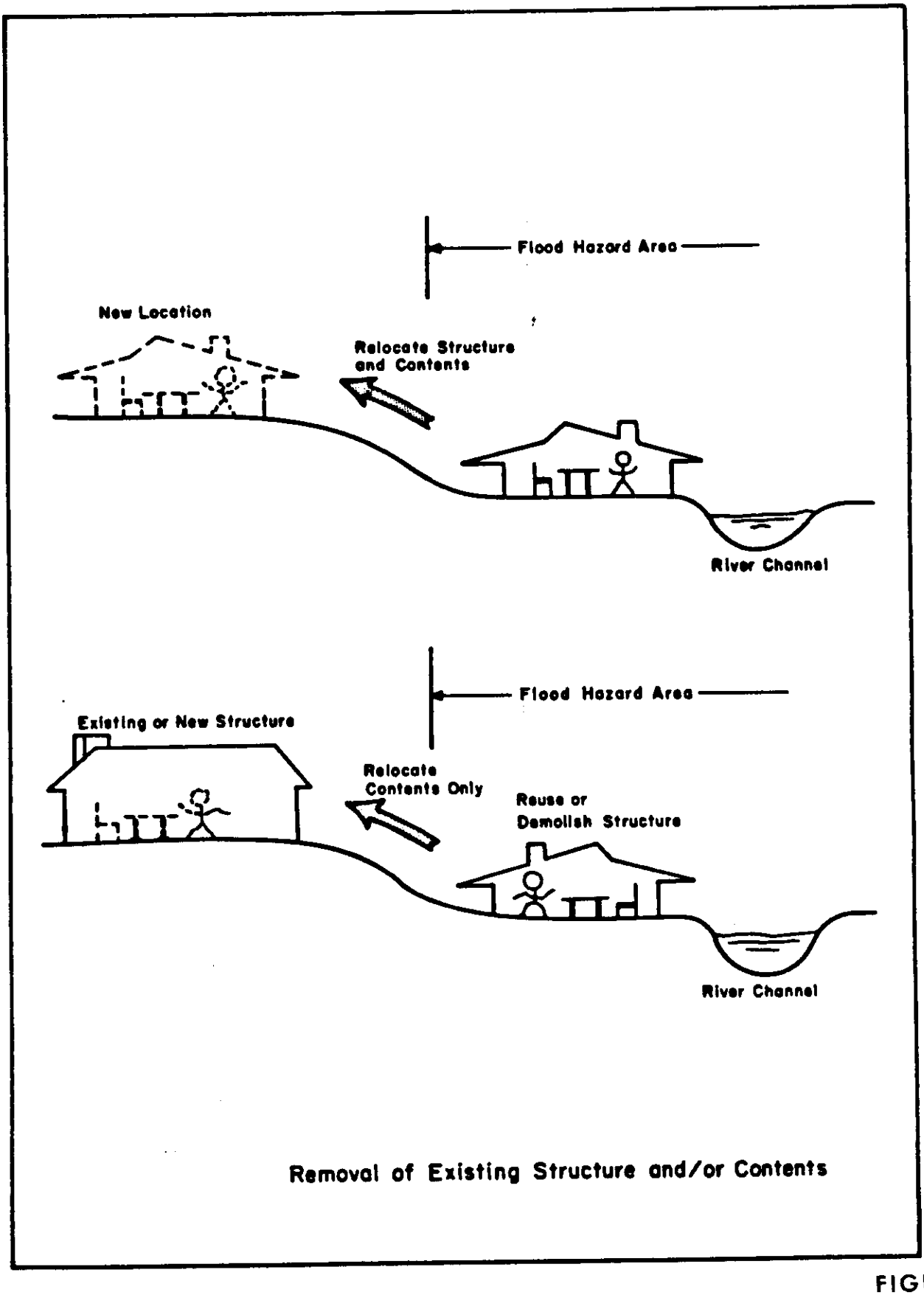

Flood Hazard Area
New Location
Relocate Structure and Contents
River Channel
Flood Hazard Area
Existing or New Structure
Relocate Contents Only
Reuse or Demolish Structure
River Channel
Removal of Existing Structure and/or Contents

FIGURE 10

VIII CONSTRUCTION IMPROVEMENTS TO EXISTING STRUCTURES

When making major improvements or repairing existing structures, water resistant materials and damage-reducing construction practices are available to reduce potential damage. Generally, this includes modifying one or more of the following: basement and/or first floor walls, floors, ceilings, exterior walls, insulation, outside utilities, and electrical heating and air conditioning systems. Specific modifications are shown in Figure 11. The numbers attached to each item listed below correspond to the numbers appearing in Figure 11.

1. Overhead energy and communications line.
2. Large space for temporary storage of contents during flood hazard.
3. Separate branch circuit above floodwater level.
4. Elevated main electrical box.
5. Elevated electrical outlets.
6. Air duct outlet for water drainage.
7. Water damage resistant cabinetry.
8. Anchored tank.
9. Elevated outside vent discharge.
10. Impermeable or damage resistant thermal and acoustical insulation.
11. Temporary outside sink drain with positive valve.
12. Water resistant wall material: polyester epoxy paint, plastic tiles, treated wood beams, etc.
13. Positive drain valve for receding water.
14. Manual control valve.
15. Sewer gate valve.
16. Sump pump for cleanup.
17. Extra wide stairway for rapid contents removal.
18. Water damage resistant carpeting.
19. Water damage resistant floor finish: linoleum, rubber, vinyl.

20, 21, 22. Weakened basement window, wall, and floor, respectively, to allow entrance of water to equalize the hydrostatic pressure that could cause structural damage.

23. Anchorage of foundation to prevent flotation and/or overturning.

Advantages

- All residential, commercial and industrial property owners can do this to one degree or another.
- It can be done on a selective basis to modify the property that is susceptible to damage.
- Damage will be reduced because of the actions taken.
- Many actions require little or no additional cost.

Disadvantages

- Flooding will still occur causing residual damage and necessitating cleanup and restoration.
- Damage will be reduced only where more appropriate construction materials and practices are used.

Physical Feasibility

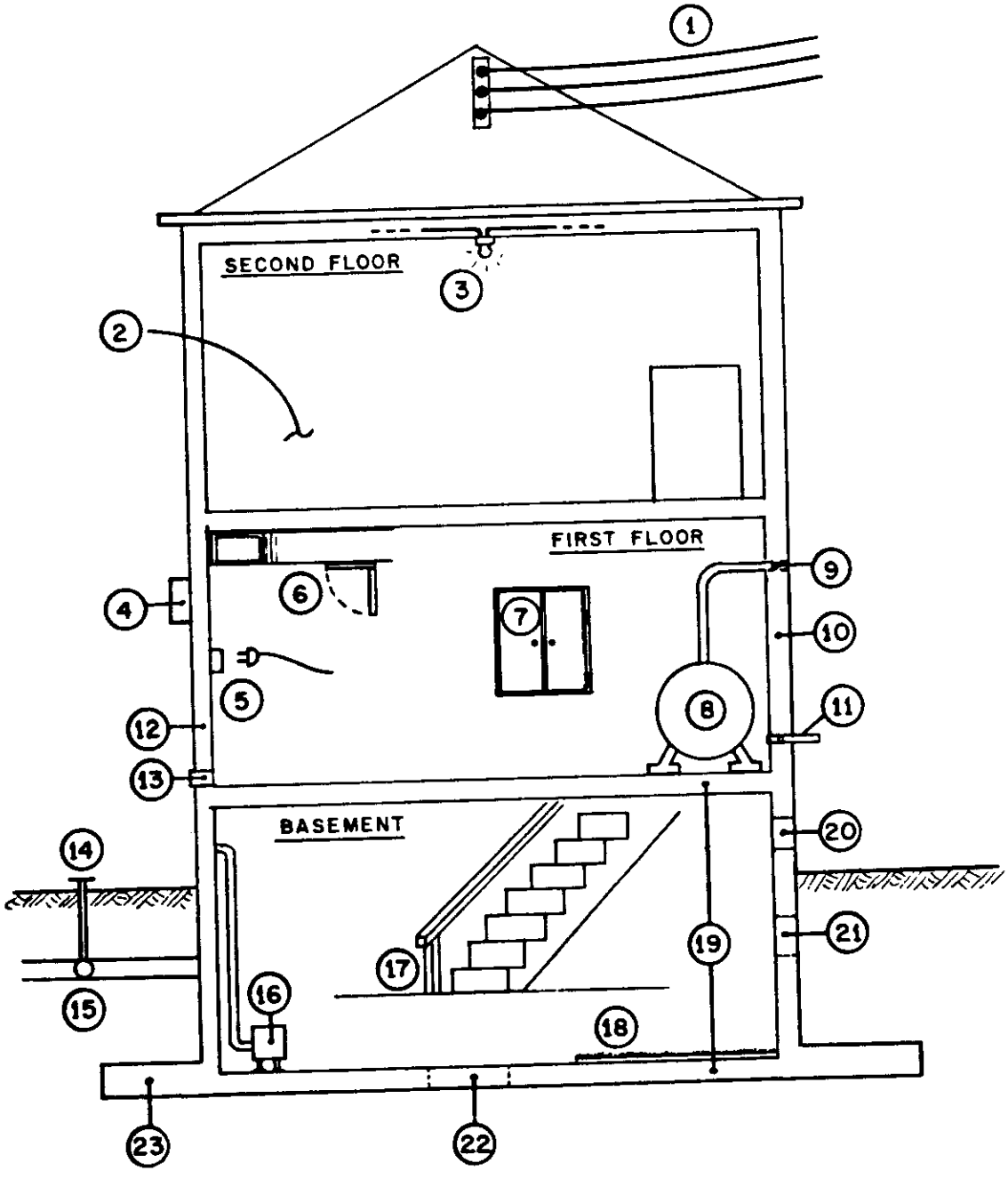
The actions described are generally applicable to all structures to one degree or another and in some combination. Their application is site specific and will depend upon the type of structure and contents, the nature of the flood hazard and the availability of other alternatives. Use of construction materials or practices to reduce potential damage appears to be most appropriate in situations where flooding is not severe or where it is the only feasible alternative—physically or economically. These actions will most likely find their greatest application in combination with other measures.

Economic Feasibility

Computation of damage reduction should be based upon estimates of damage with and without a particular water resistant material or damage-reducing construction practice. This is difficult to determine since damage is not eliminated, as it would be if some property were removed, but is simply reduced. It is felt that most actions would be economically feasible because of the low additional cost of implementation when making major improvements.

Costs

The costs of implementing such measures vary, but generally are low because they can be done as part of new construction, remodeling or repair. Often, the initial cost of implementing such actions is less than 1 percent of the total structure value.



Construction Materials and Practices to Reduce Potential Damage.

FIGURE 11

IX WHICH ACTIONS ARE FOR YOU

METHOD 1

- In general, everyone can benefit from Method 1.
- Some ideas are easy and inexpensive, but others, such as, construction of utility rooms, utlity cells and interior floodwalls are expensive and require professional assistance.
- The simplest of actions can reduce the repair cost and frustration associated with the nuisance of cleaning up after floods.

METHOD 2

- Method 2 also reduces a great deal of the cleanup effort.
- Interior flood damage is reduced.
- Even if water leaks in or rises above the height of your flood shield, you will have filtered out a lot of the sediment and debris.
- Professional advice regarding the structural stability of the building is required before adopting Method 2.

METHOD 3

- Method 3, if used properly, will significantly reduce the damage to your house.
- If you can find help, do some of the work yourself, or get building materials at a discount; these measures may cost less than you think. Remember that dike construction requires proper soils, a degree of compaction, and so on. Walls have to be constructed carefully and fit tightly. Thus, professional advice is recommended.
- These measures require less emergency action on your part. You won't have to depend as much on receiving a flood warning to implement your plan.

METHOD 4

- Method 4 would reduce all but minor nuisance damage except from the extremely large floods.
- Professional help is needed — engineers, house movers and building contractors.
- This method, in most cases, gives long term savings and is dependable.

METHOD 5

- Flood damage to contents and/or structure is reduced.
- Professional help is required.
- This method is extremely dependable in reducing flood damages.

These floodproofing ideas are wise investments if you can be sure they will save you enough money and effort to pay for themselves. If you think that doing too much or too little can be a waste, you may be right!

You may have found that the amount of money needed to finance the best combination of floodproofing is more than you can pay for all at once. In this case, you might consider a low-cost, long term improvement loan. Some people combine their floodproofing with a general remodeling plan and pay for it in one bill. Specific measures which may be incorporated into a remodeling plan can be found in Section VIII. Whether it is to your advantage to borrow money depends to some extent on how long you intend to remain at your present location. If you intend to stay despite the flooding, an investment can begin to pay you back with less flood damage in a short time.

If you cannot afford to invest or feel that you won't get your money back if you do sell, you can still make the most of a limited budget. One way is using the cost-saving measures in this report and, as much as possible, doing the work yourself. Small engineering or architectural firms may be willing to do design work and provide information on construction methods to help you along.

Another way to stretch your budget is to combine methods. For example, you can undertake measures in Method 1 first which reduces you susceptibility to damage and then determine which long range plan would be best.

X LEARN AS MUCH AS YOU CAN BEFORE BEGINNING

Each method has advantages and disadvantages, but some methods may also involve legal restrictions. For example, rewiring electrical outlets must be done according to building codes. In some communities you may be required to obtain a variance from the flood plain zoning ordinance to build a flood wall or dike, and raising a structure usually requires a building permit. You should consult with local officials during the planning stage to determine the legal requirements. The New England Division has numerous publications concerning floodproofing. Additional sources of information are shown on the last page of this report.

XI MAINTAIN THE MEASURES YOU HAVE INSTALLED

One of the unfortunate facts of life is that the things we build will not always last unless we maintain them. You should check your floodproofing measures thoroughly at least once a year and quickly look them over when you suspect flooding may be likely. Ask the following questions.

Have cracks developed?
Are valves stuck?
Have runners become rusty or warped?
Does your pump work?
Have drains become blocked?
Have small animals dug holes in your levees?

In order to protect your investment, you should check all such possibilities and make the needed repairs.

XII SUMMARY

With the exception of moving contents to areas not susceptible to floodings, most floodproofing measures require some professional help and can be costly to implement. Before deciding on a course of action, you should determine the extent of flood hazard at your site and estimate your flood damage potential. When weighing the estimated damages against the costs of various floodproofing measures, remember that the floodproofing cost estimates are based on December 1980 prices. A summary of floodproofing solutions to flood damage for structures now existing in the flood plain is listed below.

1. Modify sewer and utility lines; make adjustments to contents; move damageable items to a higher elevation in the building; and protect specific items with interior walls, cells or rooms.

2. Install seals and shields.

3. Construct a ring levee or wall around the building.

4. Elevate the structure to above the 100-year flood.

5. Move the structure and/or contents out of the flood plain.

6. Observe floodproofing construction practices when making improvements.

7. If you live in a flood plain, purchase and keep current a flood insurance policy. See your insurance agent about how to obtain a policy. If you have a specific question about the National Flood Insurance Program, call the toll free telephone number 800-424-8872, or call the Region I office in Boston, Massachusetts at (617) 223-2616.

XIII GLOSSARY

Buoyancy	The tendency of a body to float or to rise when submerged in water.
Economic Feasibility	A comparison of damage reduced by a floodproofing measures with the estimated cost of implementing the measures. The measure is termed economically feasible if the damage reduced equals or exceeds the cost.
Flood plain	The relatively flat area or lowlands adjoining the channel of a river, stream or watercourse, ocean, lake or other body of standing water that has been or may be covered by floodwater.
Hydraulic	Operated, moved or effected by means of water.
Hydrostatic Pressure	Pressure exerted or transmitted by water.
Impermeable	Not permitting passage of water.
Inundate	To cover with a flood.
Levee	An embankment of earth for preventing flooding.
Permeable	Permitting passage of water.
Sump	A pit at the lowest point of a drainage area serving as a drain.

XIV FOR MORE INFORMATION

SPECIFIC INFORMATION ON REDUCING FLOOD DAMAGES:

1. Consumer Reports, "Basement Water Proofing: Facing the Facts," July, 1974.

2. Federal Disaster Assistance Administration, "When You Return to a Storm Damaged Home," September, 1975.

3. Federal Insurance Administration, "Elevated Residential Structures, Reducing Flood Damage Through Building Design: A Guide Manual," September, 1976.

4. Federal Insurance Administration, "Economic Feasibility of Floodproofing - Analysis of a Small Commercial Building," Federal Insurance and Hazard Mitigation, June 1979.

5. Federal Insurance Administration, "Flood Emergency and Residental Repair Handbook," Federal Insurance and Hazard Mitigation, October 1979.

6. Sheaffer, John R., "Introduction to Flood-Proofing, An Outline of Principles and Methods," University of Chicago, 1967.

7. The Hartford, "Flood-Proofing, A Technique of Avoiding Flood Damage," Hartford, Conn., n.d.

8. U.S. Army Corps of Engineers, "Flood-Proofing Regulations," Washington, D.C., 1973.

9. U.S. Army Corps of Engineers, "Physical and Economic Feasibility of Nonstructural Floodplain Management Measures," Institute for Water Resources, Fort Belvoir, Virginia, March 1978.

10. U.S. Army Corps of Engineers, "Cost Report on Nonstructural Flood Damage Reduction Measures for Residential Buildings within the Baltimore District," Institute for Water Resources, Fort Belvoir, Virginia, July 1977

11. U.S. Army Corps of Engineers, "An Example of Raising a Private Residence to Avoid the Flood Hazard," South Atlantic Division, Atlanta, Georgia, 1976.

12. U.S. Department of Agriculture, "Removing Stains from Fabrics," Home and Garden Bulletin No. 62, 1976.

13. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, "Floods, Flash Floods, and Warnings," Washington, D.C., 1973.

14. SEDA - Council of Governments, "Industrial Flood Preparedness - Proceedings of Flood Warning and Floodproofing Seminar for Industry," April 1979

GENERAL FLOOD INFORMATION:

1. Flood Depth and Frequency Information
   - Army Corps of Engineers
   - Federal Emergency Management Agency
   - U.S. Geological Survey
   - Soil Conservation Service

2. Flood Insurance
   - Your insurance agent
   - Federal Emergency Management Agency

3. Engineering and Architectural Services - Check yellow pages under Consulting Engineers and/or Architects

4. Building Permits - Local officials